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The effects of DI flashcards with and without match to sample with edibles on number recognition using reduced set size and DI discrimination training: a case report

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Abstract
The purpose of this study was to the effectiveness of Direct Instruction (DI) flashcards and tangible reinforcement were effective for teaching a student in a special education preschool program to identify numbers. After several sessions of teaching number recognition with DI flashcards the participant showed a lack of progress. The first author reduced the set size and time per session in hopes of improving performance. After several sessions with the reduced set size and time there was no significant increase in performance so an alternative intervention, DI discrimination and match to sample method, was selected to teach number recognition. Another purpose of this study was to find out if the change in intervention to DI discrimination and the match to sample method paired with tangible reinforcement was successful in teaching the student to recognize numbers. A multiple baseline across number sets was used. The study was conducted in a self-contained special education preschool classroom in a public school located in the Pacific Northwest. Improvement was seen with the implementation of DI discrimination and the match to sample method. This study suggests that the use of DI discrimination and a match to sample method was effective at teaching preschool aged students to identify numbers.

Keywords: preschool student with developmental delays, number recognition, flashcards, match to sample, discrimination, tangible reinforcers, edibles, Direct instruction, model, lead, test

1. Introduction
Children with documented developmental delays tend to do poorer in school than their typically developing peers. Part C of the Individuals with Disabilities Improvement Act (1) states that the documentation of "Developmentally delayed" is "measured by appropriate diagnostic instruments and procedures in 1 or more of the areas of cognitive development, physical development, communication development, social or emotional development, and adaptive development; or (ii) has a diagnosed physical or mental condition which has a high probability of resulting in developmental delay" (1, 2). Obtaining documentation of developmental delays in Washington State requires that a developmental evaluation be performed by a highly trained professional and must show a 1.5 Standard Deviation or 25% delay in one or more areas (2). It is recognized that any delay in any of the five defined areas would impact school performance. Early childhood education and early intervention for children who have documentation of developmental delays at a young age shows that these children have an improved performance when they transition to Kindergarten (3, 4).
Students who are documented as having delays benefit greatly from intervention on academic skills. Proficiency in math skills is essential in daily life and is required for success in school and work (5). Learning basic math facts isn't just a prerequisite for solving problems, but learning these facts becomes a necessity to solve problems that are meaningful and relevant (6). Number recognition and identification is a prerequisite skill for all aspects of math, and is an area of skill that pre-kindergarten aged children are expected to be proficient in (7). Society does not only rely on our education system, it expects that students are held to high standards of success in academics which includes math (8). Difficulties in learning math are prevalent among children with disabilities (9, 7) and these same difficulties also create issues for typically developing children in general education classrooms when these students do not grasp academic concepts as they are presented (7).

The Direct Instruction (DI) flashcard system (10) has shown to be successful in teaching several academic skills. The use of DI flashcards for math skills requires the teacher to provide the student with flashcards. These flashcards should contain known and unknown facts (5). The ratio of known to unknown facts can vary from 20 to 100%, but little evidence has been found to support this notion (11, 5). The content for the flashcards is chosen based on pretests given to the student to determine which items he knows and those items that are errors. The error correction procedure is employed when the student makes an error for a certain card. This the card is placed back into the stack three to four cards from the top of the pile, so it can reappear quickly. A key part of the error correction procedure includes the teacher engaging in a model, lead, and test error correction in which the teacher models the correct response, the student and the teacher practice this response together, and finally the student is required to make a correct response to the error card (12). When the error card appears again and the student makes the correct response, the card is placed at the bottom of the pile. If the student makes an error again, the same model, lead, and test error correction procedure is implemented and the card is again placed three or four cards from the top of the pile (13, 14). This DI flashcard teaching method has been successful in teaching math facts (11, 15, 16, 17, and 18), sight words (19, 20) and colors, shapes, and numbers (21). This teaching method can be implemented in almost any academic area, the materials are inexpensive and accessible, and the skills can be taught quickly and easily (22). Teaching with flashcards has shown that student performance is higher on the post-test when compared with students who are taught using traditional methods (23). The use of DI flashcards with preschool aged children has the potential to be successful in promoting the acquisition of early math skills and number recognition which is significant for ensuring the academic preparedness will allow the young child to have success in school.

The use of the DI discrimination and match to sample method has also shown to be successful in teaching academic skills students with moderate to cognitive disabilities (24). The teaching procedure requires the student to match an item to an identical item in an array of different items. We have successfully employed DI discrimination training (25) to teach letter identification in another classroom setting.

The purpose of this study was to increase the accuracy of number recognition for a preschool aged student with documented developmental delays in a special education classroom. The goal of this study was to increase the pre-kindergarten skill of number recognition so the student would be more prepared to transition to kindergarten in the next year. Another goal of this study was to determine the success and practicality of implementing DI flashcards and DI discrimination with the match to sample method, both paired with tangible reinforcers, in a special education preschool classroom to recognize numbers.

2. Method

2.1 Participant and Setting

The participant of this study was a four-year-old African-American female with documented developmental delays. The participant's family did not have a history of developmental delays. The participant received special education services in a preschool self-contained classroom located in a public elementary and also attended a Head Start Program for part of the morning.

She was referred for special education by a local birth-3 where child had been receiving services in the areas of Speech and Language for two years. The birth-3 program used the *Battelle Developmental Inventory, Second Edition (BDI-2*) (26) to evaluate the child. The child was 2 years of age at the time of this evaluation. The child showed frustration, lack of communication skills, outbursts, difficulty participating in tasks not of her choosing, elopement, lack of social behaviors, difficulty straying from routines, and lack of eye contact. The evaluator was unable to complete the full evaluation due to non-compliance and screaming which led to a mark of "no valid score." It was recommended that the child be re-evaluated after acclimating to a pre-school setting. Those areas which were able to be scored showed delays in the areas of personal-social development, adult and peer interaction, and speech and language. Our participant's language was also assessed using *Preschool Language Scales*-Fifth Edition (PLS-5) (27) at age three which showed low scores in auditory comprehension, expressive communication, and total language. The results showed that all areas of language were developmentally delayed.

After the child was referred to special education, an individualized education plan (IEP) was developed for specially designed instruction. The IEP goals were in the following domains: communication and social behavior. Speech Therapy continued to be provided.

In addition, prior to the start of this study, it had been suggested by the school district that the participant be evaluated for pre-academic skills and autism but has not completed the testing. The lead teacher along with the Instructional Aid had concerns with getting the participant evaluated for autism. The participant required consistent repetition and review of basic academic concepts and struggled with these concepts during individual and group instruction.

The participant was selected for this study by her classroom teacher (third author) because she was to transition to kindergarten in the next school year. The teacher was concerned about this child's academic preparedness for kindergarten. She had difficulty with number recognition which is a skill required in preschool. She often vocalized the names for the numerals 1 through 5 during group instruction. However, she struggled with number recognition when she was assessed individually.

The setting for the study was a special education self-contained preschool classroom in the Pacific Northwest. The participant attended the morning session of preschool. The total number of students enrolled at the time of data collection was just two. At times the child was distracted from a number of environmental factors including other students engaging in activities with the teacher, volunteers in the classroom, and general movement of persons in the room. The first author individually worked with the participant during sessions ranging from two to five minutes minutes. The first author worked with the participant at an empty

classroom table or on the carpet away from the other students and classroom teacher. This classroom has been employed in several classroom research projects (28, 29) by preservice teacher education candidates from a local private university (30).

3. Materials

The materials used in this study were 3x5 white flashcards that each featured a single numeral handwritten in black ink by the first author. A post-it was kept on the back of each card every session to record if the participant responded correctly or incorrectly. Tangible reinforcers for correct responses, fish cracker edibles, were used each teaching session.

3.1 Dependent Variables and Measurement

The first dependent variable for the DI flashcard intervention of this study was the number of numerals correctly identified per session. A correct response was defined as the participant saying the correct numeral within 4-6 seconds of instructional cue made by the first author. The participant had language difficulties, and therefore the vocalization of the numeral did not have to be exact to count as a correct response, but needed to be a close approximation so that it was understandable to adults who regularly worked with her. The second dependent variable was the number of errors made by the participant. An error was defined as any response that occurred after 4-6 seconds of the prompt, or any incorrect response during the 4-6 seconds that was not correct. An incorrect response was saying the wrong numeral for the number presented, or any response that was not the correct number.

The first dependent variable for the DI discrimination match to sample intervention was the number of numerals correctly matched to the corresponding numeral presented in an array of two different numerals per session. The second dependent variable for the DI discrimination match to sample intervention was the number of errors made by the participant. An error was defined as any response that occurred after 4-6 seconds of the prompt, or any response during the 4-6 seconds that was not correct. An incorrect response was matching the wrong numeral to the array of two numerals presented. Also, the first author switched the order of the array of two numerals with each presentation to the participant.

3.2 Data Collection and Inter observer Agreement

Data were collected by the first author during the teaching session. The teaching sessions for DI flashcards were initially five minutes in length, then the set size and time per session were reduced to three minutes. The teaching sessions for the DI discrimination match to sample intervention included a reduction in time per session from the previous three minutes to two minutes.

The data collection throughout the different interventions remained the same. Data were collected each session on the post-its located on the back of the flashcards with the numerals in the set being presented in the session. The first author recorded a check mark for correct responses and a tick mark for incorrect responses.

For baseline no feedback to the responses were provided. During intervention specific praise, general praise, and tangible reinforcers were given for correct responses on the set that was being taught.

Reliability was taken 8 of the 23 (34.78%) sessions for the participant. Inter observer agreement data was taken once during baseline. It was taken four times during the DI flashcard intervention, two times during the DI flashcard reduced set and time intervention, and one time during the match to sample intervention. Reliability was taken by the other students completing their research projects in the classroom, the Instructional Aides for the classroom, or the master teacher. They were informed of the data taking procedures and recorded data in the same manner as the first author. Reliability was calculated by dividing the number of agreements by the number of agreements and disagreements, and then multiplied by 100. Inter observer agreement for the Participant was 100%.

3.3 Experimental Design and Conditions

A single subject, combination multiple baseline and ABCD design (31, 32, 33) across three sets of numerals was used to evaluate the effectiveness of both DI flashcards and DI discrimination match to sample procedures to teach number recognition. The participant received three days of baseline before beginning intervention. There were 3 sets of numerals for the participant. These sets of numerals were taught to the participants in a staggered fashion. New sets of numerals were introduced to the participant based on the individual participant's success with their previous numeral sets.

3.4 Baseline

During baseline, the first author individually presented numbers one through ten on flashcards. The participant was asked "What number?" They were then given 4-6 seconds to answer and the first author recorded incorrect and correct responses on the post-it on the back of the flashcard. During the baseline phase, the first author did not give the participants any positive or negative feedback in relation to their responses. The participant was encouraged to try their best and verbal praise was given for participation.

3.5 DI flashcards and number recognition

Three sets of numerals were created for the participant using numerals presented in daily lessons in their preschool classroom. The sets were chosen because the participant needed to be able to recognize the numerals daily in preschool and they will need to master this skill to succeed in math in kindergarten next year. The participant had the correct response for one known numeral from the three sets during baseline which had ten numerals total across all sets. The one known numeral was included in set 1 to build confidence. The remaining sets included a mix of numerals one through ten. Set 1 consisted of one known numeral and three unknown numerals. Set 2 consisted of three unknown numerals. Set 3 consisted of three unknown numerals.

At the beginning of each session the first author taught the participant their current set using the DI method. A model, lead, test format was employed to teach the student their set. The first author showed the participant the numeral being

taught and said, “This number is___.” Then the first author asked the participant to repeat what numeral it was. After teaching, the first author went through the current set with the participant. The first author placed any cards with an incorrect response two to three cards back in the pile and then performed error correction by utilizing the DI method of model, lead, and test. The first author gave verbal reinforcement and administered tangible reinforcement, fish crackers, for every correct response on the current set of numerals.

Data were taken for each correct and incorrect response directly on the post-it on the back of the flashcard. The first author recorded the number of correct and incorrect responses immediately after the response was given on the post-it. This was performed immediately after each response every session to record intervention data on the current set. This data collection procedure was also used to take data on the remaining sets of unknown numerals that the participant had not received instruction on after some of the teaching sessions for the current set.

3.6 DI discrimination and number recognition with reduced set and time

The same procedure and data collection for the DI flashcards intervention was used for this phase but both the time per session and the set size were reduced for each set. The time per session was reduced from five minutes to three minutes due to inattentiveness and off-task behavior towards the last few minutes of the five minute sessions. The set sizes were reduced due to a lack of an increasing trend in correct responses. Set 1 was reduced from four to two numerals, set 2 was reduced from three to two numerals, and set 3 was reduced from three to two numerals. Due to the reduced set size, the first author placed any cards with an incorrect response one card back in the pile and then performed error correction by utilizing the DI method of model, lead, and test. The first author administered tangible reinforcement, fish crackers, for every correct response on the current set of numerals. The first author recorded the number of correct and incorrect responses on the post-it on the back of the flashcard.

3.7 DI discrimination and match to sample with reduced time

After session 20, the Participant was not showing enough progress in the prior interventions. Set 1 was then taught with the DI discrimination match to sample method. The same reduced set of numerals developed for the previous DI flashcard intervention was used for the same reasons they were previously chosen. The session time was reduced from three to two minutes for the same reasons for the previous reduction in time.

At the beginning of each session the first author taught the participant their current set using the DI method. A model, lead, test format was employed to teach the student their set. The first author showed the participant the numeral being taught and said, “This number is___.” Then the first author asked the participant to repeat what numeral it was. Then the first author gave the participant a flashcard with a numeral printed on it and said, “Match to same” with an array of the two flashcards with numerals from the current Set 1 printed on them. The simplified cue “Match to same” was used to accommodate the student’s language delays. The first author showed the participant how to find the numeral and match it with the corresponding numeral from the array of two flashcards. After teaching the first author went through Set 1 with the participant. The first author then performed error correction by using the DI method of model, lead, and test. The first author administered tangible reinforcement, fish crackers, for every correct response on the current set of numerals. The first author recorded the number of correct and incorrect responses on the post-it on the back of the flashcard. The first author recorded the number of correct and incorrect responses on the post-it on the back of the flashcard.

4. Results

Overall results of this study showed a higher increase in numeral recognition for Set 1 during the DI flashcard reduced set and time intervention and the match to sample and reduced time intervention. The overall results are represented in Figure 1.

4.1 Baseline

During the first three sessions of baseline, the results of expressive numeral recognition were low enough to justify intervention.

The numerals 1 through 10 were divided into three sets that were presented to the participant in a multiple baseline design across sets. The participant consistently recognized few numerals. Across the initial 3 sessions of baseline the participant correctly identified an average .17 numerals out of the four numerals in Set1. For the remaining sets the participant identified zero numerals.

4.2 DI flashcards and Number Recognition

The results of the DI flashcards for number recognition are shown in phase B of Figure 1. During this initial intervention in sessions 4 through 15 the student did not show a significant increase in correct responses. With the intervention of DI flashcards, the Participant was able to recognize an average of .25 numerals out of the four numerals for Set 1 when shown the number printed on the flashcard.

4.3 DI Flashcards and Number Recognition with Reduced Set and Time

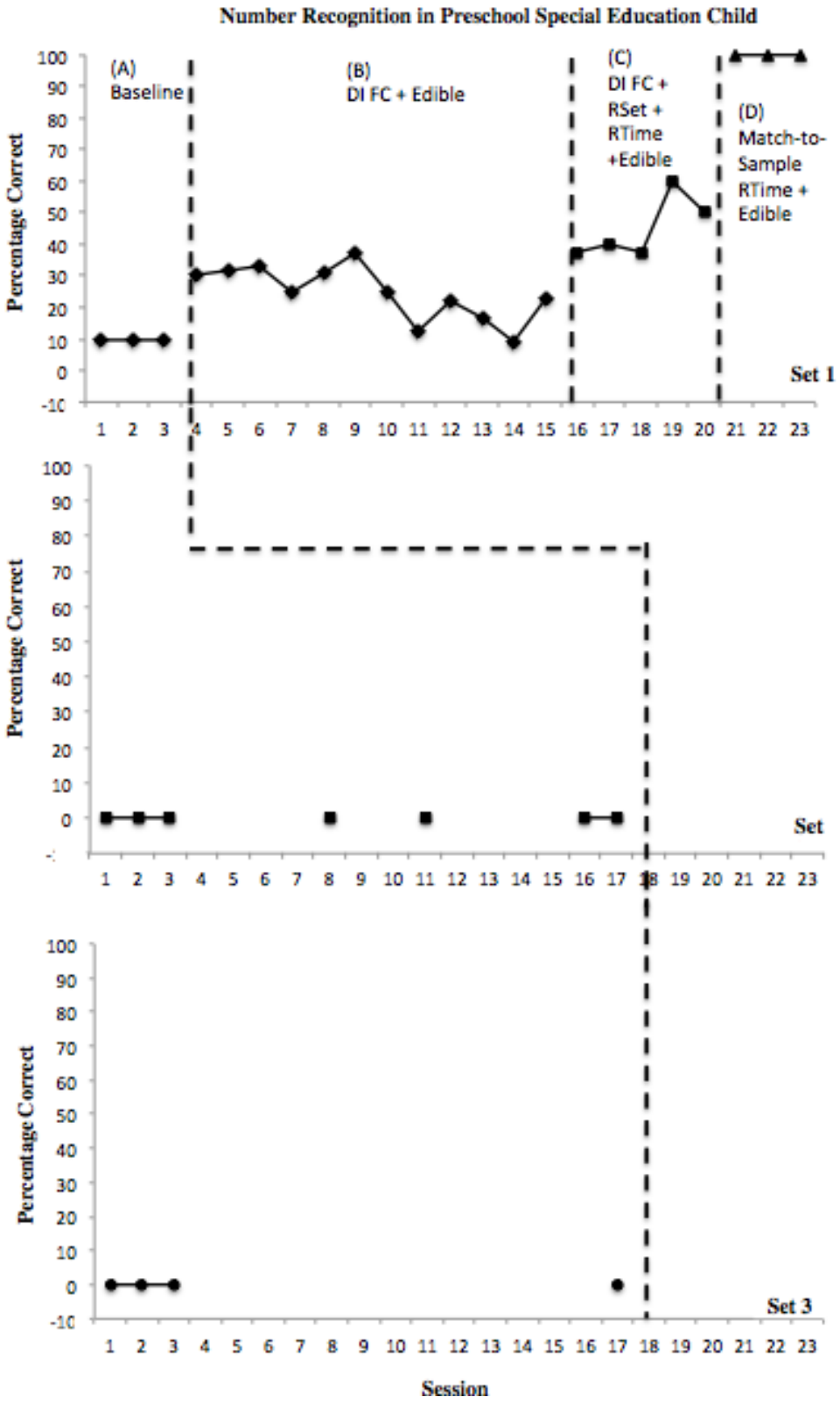

Figure 1. Percent of correct numerals identified per session by the Participant is shown across three sets. During phase B Set 1 had a possible total of four correct numerals, Sets 2 and 3 had a possible total of three letters correct. During phase C Sets 1, 2, and 3 had a possible total of two numerals correct. During phase D Set 1 had a possible total of two numerals correct.

The results of the DI flashcards for number recognition with a reduced set size of two numerals per set and a reduced session time from five minutes to three minutes are shown in phase C of Figure 1. During this intervention in sessions 16 through 20 the student showed a slight increase in correct responses. With the intervention of DI flashcards and a reduction in set size and time per session, the Participant was able to recognize an average of .45 of the numerals out of the two numerals for Set 1 when shown the number printed on the flashcard.

4.4 DI discrimination and Match to Sample

The results of using DI discrimination and match to sample method showed an increased level of performance.

The intervention was implemented for the reduced Set 1 consisting of two numerals and was only implemented on sessions 21 through 23. Following the implementation DI discrimination and match to sample, the participant was able to match two out of the two numerals for Set 1 when presented with the number printed on the flashcard and asked to match to the corresponding number.

5. Discussion

Overall, the DI flashcards were not very effective for the participant, but the reduction of the set size and time per session showed a slight increase in performance. The failure to obtain large gains replicates some of our prior research with very young children (34). The set sizes and time per session were reduced as a result of the participant showing heavy off-task and non-compliant behaviors and a lack of increased performance. Even with the reduction in set size and time the participant did not show enough progress. This is why DI discrimination and match to sample method with a reduction in time per session was implemented. The DI discrimination and match to sample method with a reduction in time per session showed great improvement for Set 1 in the last three sessions. During the match to sample intervention the participant showed mastery of the numerals 1 and 2. The use of a single case research design allowed the implementation of various procedures until mastery was obtained. Unfortunately, we were unable to implement DI discrimination training and reduced set size with Sets 2 and 3 due to the ending of the semester. A replication (31-33) of these procedures needs to take place.

The failure of the present case report to replicate a large body of research (35, 13, 12, 5, and 14) needs further analysis as well. It may reflect on the age as well as the severity of the child's disability. This issue needs further clarification.

The participant's willingness and ability to work with the first author without significant off-task and non-compliant behaviors varied greatly between sessions. When the first author would tell the participant it was time to participate in the activity they would sometimes say, "No," would yell, run, or go to another activity of their choosing. When this occurred, the first author would say "come sit, time to work for crackers" or "numbers first, then _____ (preferred activity)." The first author also allowed the participant to ask for 30-second breaks which seemed to assist in maintaining on-task behavior during sessions. The use of a weighted vest was also employed on some sessions where non-compliance and self-stimulation behaviors were apparent. The weighted vest was often used throughout the day in the preschool classroom. The first author also said "sit on pockets" and pushed the participant's chair in which seemed to increase attentiveness and willingness to participate in the activity. Specific reinforcement for on-task behaviors was given to encourage participation.

The participant increased their amount of numeral recognition after the set size and time per session were reduced. The student required heavy prompting and consistent tangible reinforcement for correct responses to maintain on-task behavior and compliance. The participant responded well to the consistent use of tangible reinforcers, fish crackers, which were used to motivate her to work. She seemed to enjoy working for the fish crackers and would say "more cracker" to which the first author would say "working for cracker" in sequence with "what number" or "match to same." She would receive specific praise and a fish cracker for every numeral correctly identified within 4-6 seconds. The edible was available at each session so the participant was motivated to work during most sessions.

The participant's language and communication skills were limited so the first author used simplified prompts. The first author employed the use of the cues "look at card," "what number," and "match to same" to prompt the participant. During baseline and the first few sessions of the initial intervention the participant often responded "two" for every numeral or with the letter "E." Even directly after the first author used the model, lead, test procedure, when asked "What number?" she would often say "two" for all numbers or "E." After the first few sessions of instruction the response "E" was extinguished. Once the intervention was changed to match to sample she caught on very quickly and achieved mastery with Set 1 after three sessions. Finally, the first author thinks the participant's lack of progress during the DI flashcard interventions was due to their lack of language skills and the requirement of a verbal response. It was also observed that the participant showed echoic behaviors and struggled with auditory processing. The lack of progress during the DI flashcard interventions may have been due to the participant simply repeating the numeral back to the first author after the correction procedure but not processing the correlation between the visual representation and the names of each number.

The first author also thinks that the mastery of Set 1 in the match to sample intervention was due to the absence of the required verbal response in the previous interventions. The match to sample intervention showed student's ability to discriminate visual representations of numerals and subsequent success in matching the correct numeral in an array of two numerals.

The DI discrimination and match to sample method was successful but would likely be an impractical intervention for a teacher to implement if the teacher cannot or does not have someone to work with the students one-on-one. In order to ensure accuracy, the teacher has to watch the student's immediate response, which can only be done if they are watching the student independently. It is possible to work with the students in a group and take turns with matching but would most likely result in a high level of off-task behaviors with the students who were not taking a turn.

The materials needed for the interventions were easily made and inexpensive. The only materials used included flashcards numerals written on them in black pen, post-it notes to take data, and fish crackers or tangible reinforcers. All of these items could be bought at a local store or provided by the school.

The third author had already had concerns for the participant and their readiness for kindergarten the next year. The main concern was that the student would go from a self-contained preschool classroom with instructional aides to a regular education kindergarten classroom with no assistive services aside from occasional Speech Therapy. The student has also never been diagnosed with Autism Spectrum Disorder even

though they show many of the behaviors seen with moderate to severe autism. The master teacher said that this project gave her evidence to get the student screened for pre-academic skills, which would hopefully result in providing her with a more appropriate education and related services.

The first author had hoped that the interventions would be successful in helping the student improve with number recognition but the outcomes of this study did not show much progress due to the first author only intervening on Set1. Number recognition like pre-reading skills is so crucial to students' future success in the schooling process (36, 37, 38, and 10). The participant showed an improvement in number recognition through the use of discrimination and match to sample techniques. Future research should be done to see if these methods are effective with other students with similar developmental delays, and if these procedures could be used to teach other math skills.

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